Claims

1. An injector for injecting fluids from a syringe into an animal subject, having an air detector for detecting the presence of an air passing from said syringe to said animal subject, said injector comprising:

a plunger drive ram,

a motor for moving said plunger drive ram,

a syringe mounting for attachment to a syringe to position a syringe relative to said injector to permit said plunger drive ram to engage and move a plunger within said syringe,

an air detector positioned in spaced relation to said plunger drive ram to engage a wall of said syringe, said air detector including a signal source emitting an air detecting signal for transit through fluid or air contained within said syringe, a signal receiver for detecting said air detecting signal after transit through fluid or air contained within said syringe, said air detector generating a warning signal if the air detecting signal received by said signal receiver indicates the presence of air within said syringe, and

a control circuit controlling said motor to move said ram and plunger to inject fluid from said syringe, said control circuit responding to said warning signal by preventing movement of said ram to prevent air from being injected into said subject.

2. The injector of claim 1 wherein said signal source is a light emitting diode, and said air detecting signal is an electromagnetic signal.

3. The injector of claim 1 wherein said signal source is an ultrasonic transducer, and said air detecting signal is an acoustic signal.

4. The injector of claim 1 wherein said injector further comprises a housing, said syringe being mountable extending external to said housing, and said injector further comprises a post extending outwardly from said housing, said air detector being mounted to said post.

5. The injector of claim 4 further comprising a syringe having a cylindrical barrel, a plunger snugly slidable in said cylindrical barrel, a discharge tip in fluid communication with said cylindrical barrel, and a outwardly-projecting section positioned on said discharge tip,

wherein said syringe, when mounted to said injector, presses said outwardly-projecting section against said air detector, to facilitate transmission of said air detecting signal into said discharge tip of said syringe.

6. The injector of claim 5 wherein said outwardly-projecting section of said syringe is a circumferential collar surrounding said discharge tip.

7. The injector of claim 5 wherein said signal source is a light emitting diode, and said air detecting signal is an electromagnetic signal, said syringe being configured to substantially reflect said electromagnetic signal from an interior wall of said discharge tip and toward said signal

receiver only when said discharge tip contains fluid.

8. A syringe for mounting to an injector having an air detector, said syringe comprising:

a cylindrical barrel,

a plunger snugly slidable in said cylindrical barrel,

a discharge tip in fluid communication with said cylindrical barrel, and

a outwardly-projecting section positioned on said discharge tip, said section being configured to substantially transmit an air detecting signal received externally of said section into an interior of said discharge tip for reflection from an interior wall of said discharge tip back through said section.

9. The syringe of claim 8 wherein said outwardly-projecting section of said syringe is a circumferential collar surrounding said discharge tip.

10. The syringe of claim 9 wherein said collar has a concave cross section and forms a lens for focussing light received from external to said collar into said discharge tip of said syringe.

11. An injector for injecting fluids from a syringe into an animal subject, having a hand-operated movement control for controlling movements of said injector, said injector comprising:

a plunger drive ram,

a motor for moving said plunger drive ram,

a syringe mounting for attachment to a syringe to position a syringe relative to said injector to permit said plunger drive ram to engage and move a plunger into or out of said syringe,

a control circuit controlling said motor to move said ram and plunger to inject fluid from said syringe, and

a hand-operated movement control comprising a lever movable between a home position and forward and reverse positions,

said control circuit responding to movement of said lever to a forward position by

moving said plunger drive ram into said syringe to expel fluid from the syringe, said control circuit responding to movement of said lever to a reverse position by moving said plunger drive ram out of said syringe to draw fluid into the syringe.

12. The injector of claim 11 wherein said lever is mounted in said injector on a pivot shaft, and further comprising return springs positioned on opposite sides of said lever such that rotation of said lever away from said home position bends said return springs.

13. The injector of claim 12 further comprising a rotational detector attached to said pivot shaft for rotation with said lever to detect an angle of rotation of said lever to produce a rotation angle signal, wherein said control circuit responds to said rotation angle signal by moving said plunger drive ram at a speed related to said rotation angle signal.

14. The injector of claim 13 wherein said control signal moves said plunger drive ram at a speed proportionate to said angle of rotation of said lever.

15. The injector of claim 13 wherein said rotational detector is a rotary potentiometer.

16. The injector of claim 12 further comprising a rotational detector attached to said pivot shaft for rotation with said lever to detect an angle of rotation of said lever to produce a rotation angle signal, wherein said control circuit responds to said rotation angle signal by moving said plunger drive ram so as to generate an injection pressure related to said rotation angle signal.

17. The injector of claim 12 wherein said return springs and said lever are electrical contacts, and further comprising a safety circuit generating a safety control signal indicating

whether there is electrical contact between said return springs and said lever,

said control circuit responding to said safety control signal,

whereby the failure of a return spring is electrically detectable by said control circuit.

18. The injector of claim 12 further comprising a detent spring positioned relative to said lever to engage said lever upon rotation of said lever into a position which is more than a predetermined angle from said home position, said detent spring producing additional resistive torque opposing rotation of said lever away from said home position beyond said predetermined angle.

19. The injector of claim 18 wherein said detent spring is positioned relative to said lever to engage said lever upon rotation of said lever to a reverse position.

20. The injector of claim 19 wherein said detent spring and said lever are electrical

contacts, further comprising a detent circuit generating a detent signal indicating whether there is electrical contact between said detent spring and said lever,

said control circuit responding to said detent signal by moving said plunger drive ram out of said syringe to draw fluid into said syringe at said predetermined recommended maximum speed.

21. An injector for injecting fluids from a syringe into an animal subject, comprising:

a plunger drive ram,

a motor for moving said plunger drive ram,

a syringe mounting for attachment to a syringe to position a syringe relative to said injector to permit said plunger drive ram to engage and move a plunger into or out of said syringe,

an electronic display displaying information regarding the activities and state of operation of said injector, said display capable of displaying information in at least a first and a second orientation,

a tilt sensor generating a tilt angle signal indicative of an angle of tilt of said injector relative to the direction of Earth gravitation, and

a control circuit connected to said motor and said display, controlling said motor to move said ram and plunger to inject fluid from said syringe, and generating display information and delivering said display information to said display,

wherein said display is responsive to said tilt angle signal to display said display information in said first orientation in response to a first range of values of said tilt angle signal, and to display said display information in said second orientation in response to a second range of values of said tilt angle signal.

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~~22.~~ The injector of claim ~~21~~ wherein said display comprises display elements arranged in positions to produce numerals in either an upright or inverted orientation.

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~~23.~~ The injector of claim ~~22~~ wherein said display is a light emitting diode display.

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~~24.~~ The injector of claim ~~21~~ wherein said display is a matrix of evenly-spaced pixels which can be selectively activated to, in combination, for graphics or characters for display.

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~~25.~~ The injector of claim ~~21~~ wherein said control circuit is responsive to said tilt angle signal to determine a speed of motion of said motor.

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~~26.~~ The injector of claim ~~25~~ wherein said control circuit operates said motor at a first speed if said tilt angle signal indicates that said injector is tilted upward with an outlet of said syringe elevated above said syringe, and said control circuit operates said motor at a second speed slower than said first speed if said tilt angle signal indicates that said injector is tilted downward with an outlet of said syringe positioned below said syringe.

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7 ~~27.~~ The injector of claim 1 ~~21~~ further comprising a hand-operated movement control connected to said control circuit for generating a movement signal, said control circuit responsive to said movement signal to cause motion of said motor in a direction indicated by said movement signal, said control circuit further responsive to stored programming to automatically move said motor to perform an injection,

wherein said control circuit is responsive to said tilt angle signal to inhibit automatic movement of said motor in response to stored programming unless said tilt angle signal indicates that said injector is tilted within a predetermined range of angles relative to Earth gravitation.

8 ~~28.~~ The injector of claim 1 ~~21~~ wherein said control circuit is further responsive to said tilt angle signal to generate display information warning an operator against performing an injection if said tilt angle signal indicates that said injector is tilted within a predetermined range of angles relative to Earth gravitation.

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~~25~~. An injector for injecting fluids from a syringe into an animal subject, comprising:

a plunger drive ram,

a motor for moving said plunger drive ram,

a syringe mounting for attachment to a syringe to position a syringe relative to said injector to permit said plunger drive ram to engage and move a plunger into or out of said syringe,

a tilt sensor generating a tilt angle signal indicative of an angle of tilt of said injector relative to the direction of Earth gravitation, and

a control circuit connected to said motor and controlling said motor to move said ram and plunger to inject fluid from said syringe, said control circuit being responsive to said tilt angle signal to determine a speed of motion of said motor.

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~~26~~. The injector of claim ~~25~~ wherein said control circuit operates said motor at a first speed if said tilt angle signal indicates that said injector is tilted upward with an outlet of said syringe elevated above said syringe, and said

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control circuit operates said motor at a second speed which is slower than said first speed if said tilt angle signal indicates that said injector is tilted downward with an outlet of said syringe positioned below said syringe.

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~~31.~~ The injector of claim ~~29~~ further comprising a hand-operated movement control connected to said control circuit for generating a movement signal, said control circuit responsive to said movement signal to cause motion of said motor in a direction indicated by said movement signal, said control circuit further responsive to stored programming to automatically move said motor to perform an injection,

wherein said control circuit is responsive to said tilt angle signal to inhibit automatic movement of said motor in response to stored programming unless said tilt angle signal indicates that said injector is tilted within a predetermined range of angles relative to Earth gravitation.

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12 ~~32.~~ The injector of claim 9 ~~29~~ wherein said control circuit is further responsive to said tilt angle signal to generate display information warning an operator against performing an injection if said tilt angle signal indicates that said injector is tilted within a predetermined range of angles relative to Earth gravitation.

33. An injector for injecting fluids from a syringe into an animal subject, comprising:

a housing,

a plunger drive ram mounted within said housing,

a motor for moving said plunger drive ram into and out of said housing,

a face plate mounting on an external surface of said housing for receiving a detachable face plate used to position a syringe relative to said injector housing to permit said plunger drive ram to engage and move a plunger into or out of said syringe, said face plate including one or more sources of magnetic field energy, the presence or absence or orientation of said sources in a given

face plate being indicative of attributes of said face plate and of a syringe type which can be mounted to said injector using said face plate,

one or more magnetic conductors of magnetically permeable material extending from said face plate mounting through said housing, positioned to channel magnetic field energy from said one or more sources into said housing, and

a control circuit connected to said motor and controlling said motor to move said ram and plunger to inject fluid from said syringe, said control circuit including one or more magnetic field detectors positioned inside said housing adjacent said magnetic conductors to detect magnetic fields channeled into said housing by said magnetic conductors, said control circuit being responsive to said magnetic field detectors to identify a face plate mounted to said injector based on the presence or absence or orientation of magnetic field energy detected by said magnetic field detectors, and to move said motor in a manner appropriate for a syringe type which can be mounted to said injector using said face plate.

34. An injector for injecting fluids from a syringe into an animal subject, comprising:

a plunger drive ram,

a motor for moving said plunger drive ram,

a syringe mounting for attachment to a syringe to position a syringe relative to said injector to permit said plunger drive ram to engage and move a plunger into or out of said syringe,

a hand-operated movement control for generating a movement request signal indicating movements of said plunger drive ram desired by an operator,

an encoder connected to said motor for generating a motion signal indicative of motion of said plunger drive ram,

a motor control circuit connected to said motor, said hand-operated movement control and said encoder controlling said motor to move said ram and plunger to inject fluid from said syringe, said motor control circuit being responsive to said movement request signal to instruct said motor to move said plunger drive ram, said motor control circuit further generating a state signal indicating

a state of operation of said motor control circuit for delivery through a monitor interface of said motor control circuit, said state signal indicating at least whether said motor control circuit is responding to said movement request signal by moving said motor,

a motor monitor circuit connected to said hand-operated movement control, said encoder, and said monitor interface of said motor control circuit, monitoring said movement request signal, said motion signal and said state signal, said motor monitor circuit confirming that said state signal is consistent with said movement request signal and said motion signal, by at least confirming that when said movement request signal indicates that movements of said motor are desired, and said state signal indicates said motor control circuit is responding to said movement request signal to move said motor, said motion signal indicates said motor is moving in accordance with said movement request signal.

35. The injector of claim 34 wherein said motor monitor circuit generates an alarm signal if said state signal is not consistent with said movement request signal and said motion signal.

36. The injector of claim 35 wherein said motor is responsive to said alarm signal to disable further motion of said plunger drive ram when said monitor circuit is generating said alarm signal.

37. The injector of claim 34 further comprising

a console for permitting an operator to specify a program of desired motion of said plunger drive ram,

a console control circuit connected to said console for obtaining and storing a program of desired motion specified by an operator,

said console control circuit generating said movement request signal in response to said stored program of desired motion.

38. The injector of claim 37 wherein said console control circuit generates a console state signal indicative of operation of said console control circuit, and further comprising a console monitor circuit for communicating with said console control circuit to obtain said console state signal, said console monitor circuit further communicating with said motor monitor circuit whenever said console control circuit is generating said movement request signal to confirm said motor control circuit is responding to said movement request signal as determined by said motor monitor circuit.